1 Examples

Plastics may be appropriately introduced by a few examples of applications in building. These will help to put them into context.
Plastics are used in three principal ways: structural and semistructural, nonstructural, and as auxiliaries to other materials and building components.

Structural and semistructural
Plastics may make up either the primary load-bearing elements or secondary members that transmit loads to primary elements made of other materials. Primary elements are almost invariably reinforced, commonly with glass fiber (Chapter 5), to increase their strength and stiffness (Chapter 3). They are often combined with other materials to provide composites having properties unattainable by the constituents acting alone.

For structural and semistructural applications plastics offer advantages useful to the designer, and limitations which must be circumvented.

Among the advantages are:

Formability: Plastics have no inherent form but must be given desired shapes (Chapters 5, 6). This makes possible efficient forms, such as three-dimensional curved shells, folded plates, ribs and corrugations, variations in thickness, and sandwiches.

Strength, Toughness, and Lightness: Reinforced plastics (Chapters 3, 5) can achieve great strength and, in common with many other plastics, high resistance to impact. This often permits thin, lightweight sections to be employed when many other materials would have to be heavy and thick.

Light Transmission: Thin structural plastics can transmit a high percentage of incident light, thus providing structure, enclosure, and illumination—a combination unique among structural materials.

Among the major limitations are:

Low Stiffness: This is often the limiting factor and makes imperative the employment of shells and other efficient forms.

Cost: The cost per pound is not low; every pound must therefore be stretched to its utmost.

Durability and Fire Resistance: Plastics may or may not be durable for a given application. *Resistance to fire similarly may or may not be* adequate. Both factors must be considered when carrying out a design. (Chapters 3, 5).

Nonstructural
The greatest quantity and the largest number of different uses of plastics in building are in nonstructural applications. It is impossible to list them all (see Chapter 4). Floor and wall coverings, facings, natural and artificial illumination, insulation, water and vapor barriers, hardware, moldings and trim, counters and furniture, ducts, piping, fixtures, and many more take advantage of one or more attributes of plastics, such as formability (Chapter 6), resistance to environmental attack, light transmission and color, low weight, impact resistance, and many others.

Auxiliaries
In some important applications plastics are auxiliaries to other materials. They may be conspicuous or may not appear at all. Among the most important are:

Coatings: Plastics films are laminated to plywood, metal, cement-asbestos, hardboard, and other substrates for both decoration and protection. Plastics are important constituents of paints, varnishes, lacquers, enamels and other coatings, frequently effecting far-reaching changes in their properties, uses, and methods of application.

Adhesives: The major engineering adhesives, counted upon for strength and durability, are based upon plastics. Waterproof plywood; laminated timber; particle boards; the bonding of glass, metal, and other smooth hard materials; the bonding of concrete, tile, and other masonry components; are all made possible by polymeric adhesives and cements. Furniture and assembly adhesives are largely based upon plastics emulsions.

Sealants: Curtain walls, expansion and control joints, and large glass areas are commonly sealed with polymeric sealants and gaskets because of their ability to accommodate large movements caused by extreme temperature changes, their ability to bond well to a great variety of surfaces when properly applied, and their durability.

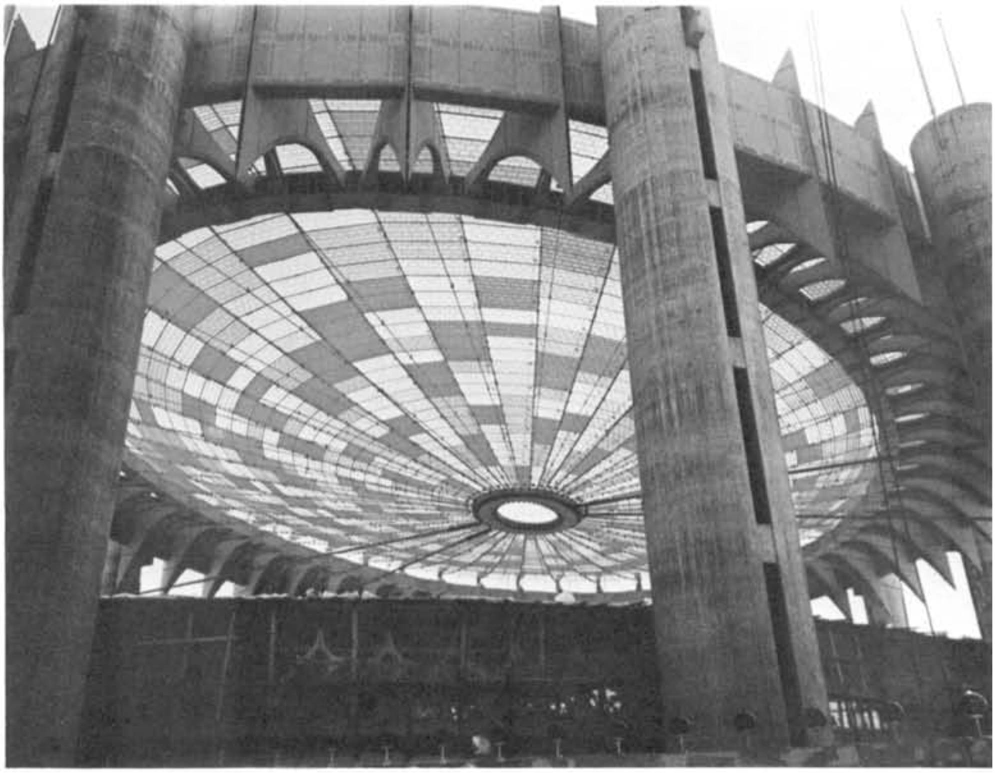
The following pages illustrate a few examples of plastics as used in buildings.

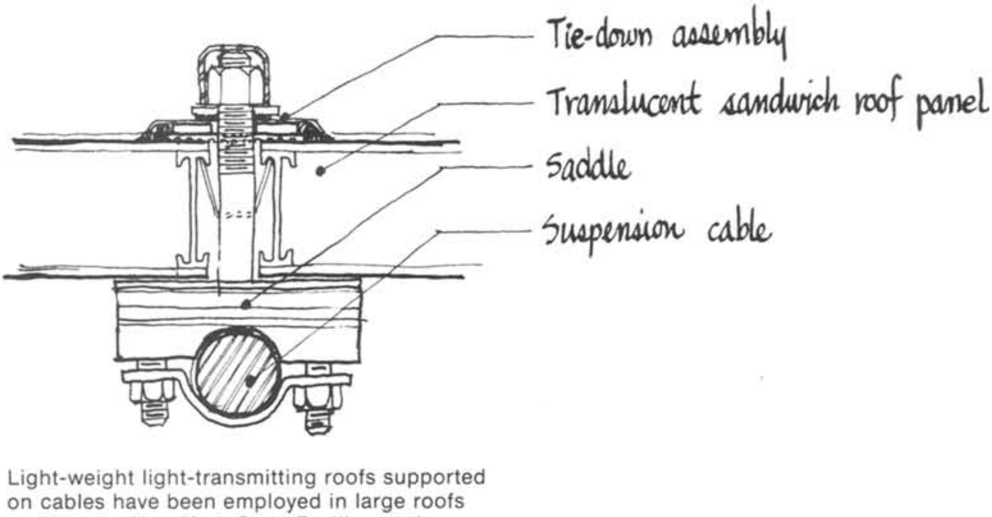
Base and control spaces of this tower are enclosed with sandwich panels having facings of random chopped glass-fiber reinforced plastic facings bonded to a core grid of aluminum extrusions. Panels are highly translucent.

Newark Airport Tower

Newark
Airport
Tower at
Dusk

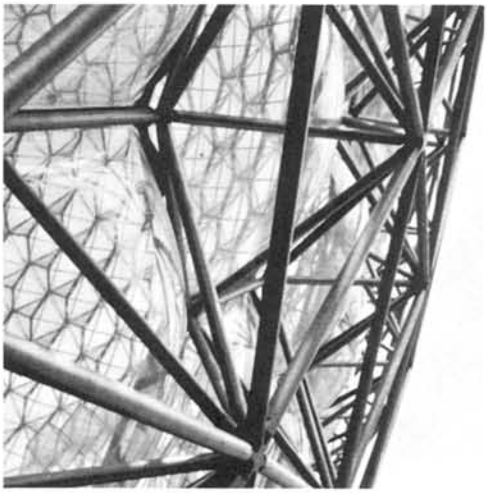
New York State Pavilion. New York Fair



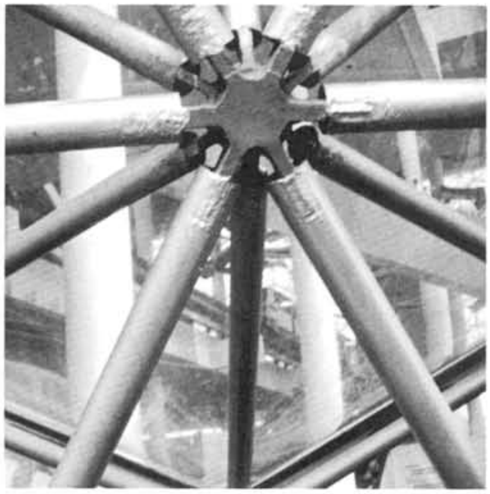


Light-weight light-transmitting roofs supported on cables have been employed in large roofs such as the New York State Pavilion at the New York Fair. Sandwich panels (Chapter 5) of glass fiber reinforced polyester facings bonded to a grid of small aluminum extrusions spanned distances up to 17 feet from cable to cable. Special flexible gasketted joints permitted each panel to expand and contract without interference from its neighbors, allowed for wind undulation, and compensated for changes in length of the cables with temperature.

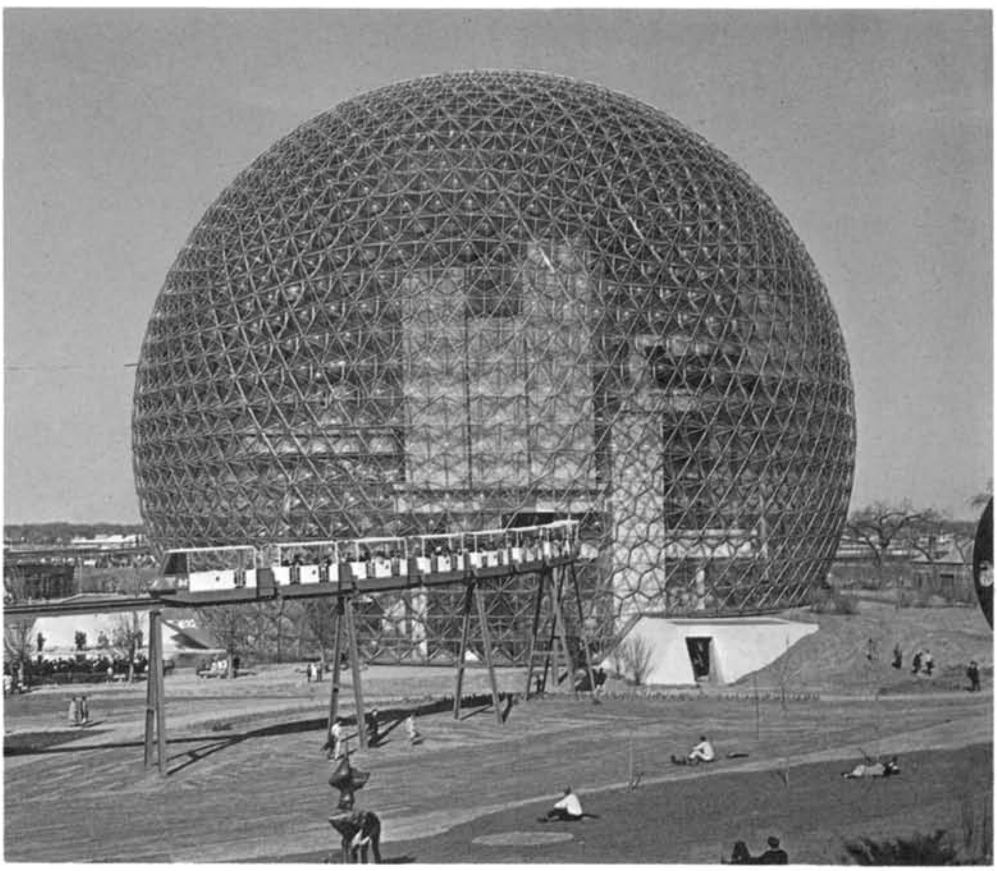
The United States Building at the World's Fair Expo '67 in Montreal consisted of a spherical space frame 200 feet in diameter, made up of metal bars in a hexagonal and triangular arrangement. To the frame were attached enclosing vacuum-formed acrylic bubbles (Chapter 6) sealed with elastomeric gaskets. Color of the transparent bubbles varied from clear at the bottom to gray at the top to avoid glare and intense sunlight.



Metal Grid and Bubbles



Joint Detail

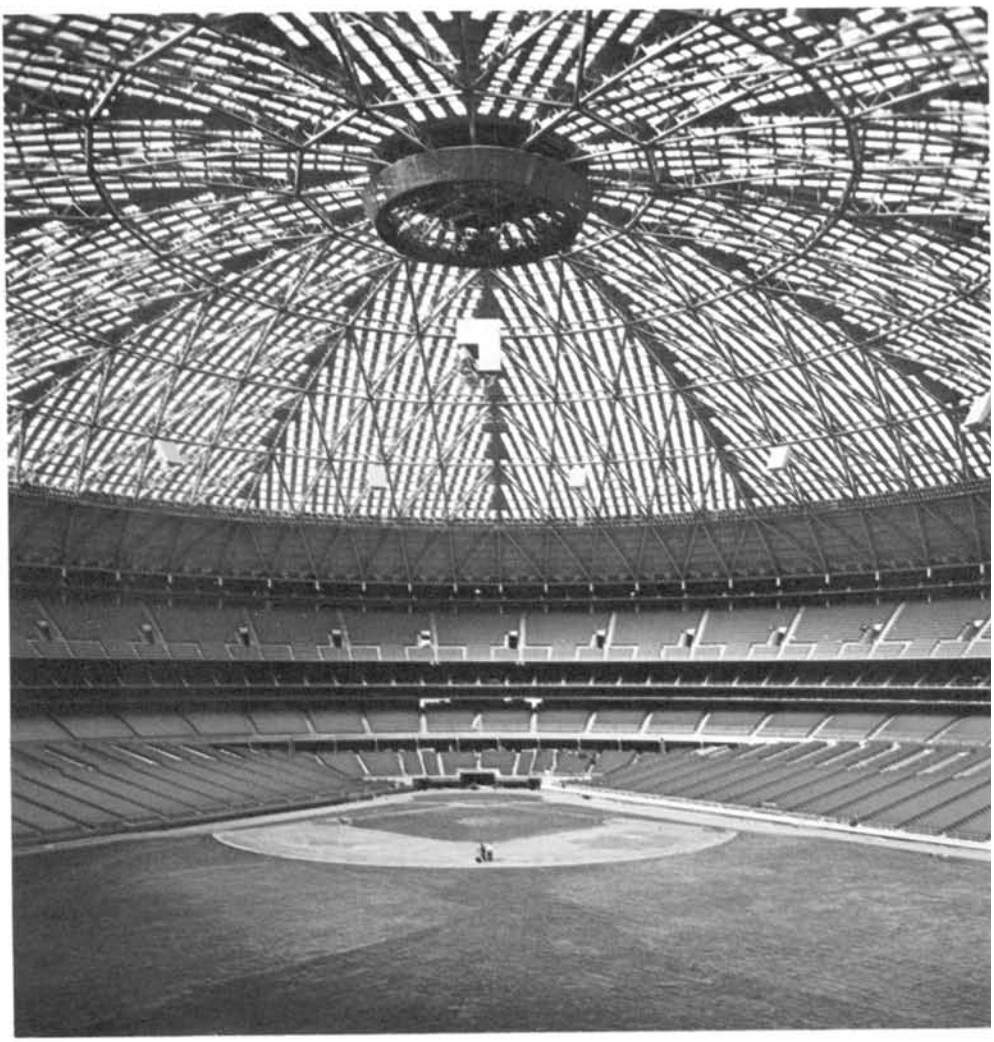


United States Building, Expo '67 Montreal

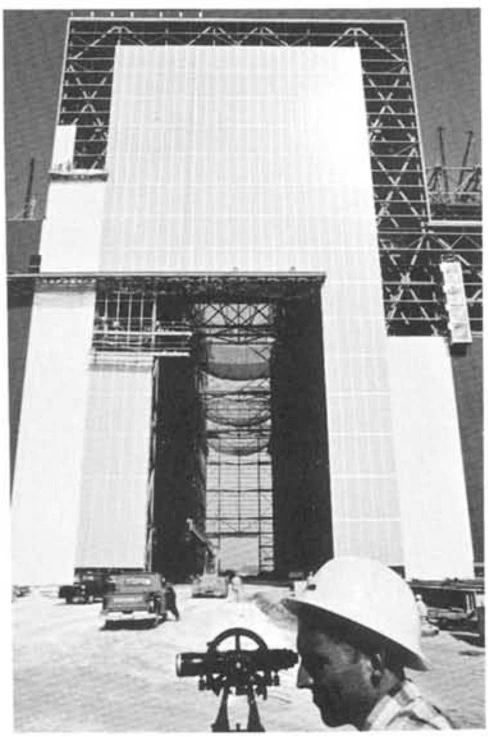
Vacuum-formed acrylic bubbles (Chapter 6) mounted on a steel primary structural frame provide the light-transmitting domed roof of the Houston stadium.

Astrodome, Houston, Texas

Interior

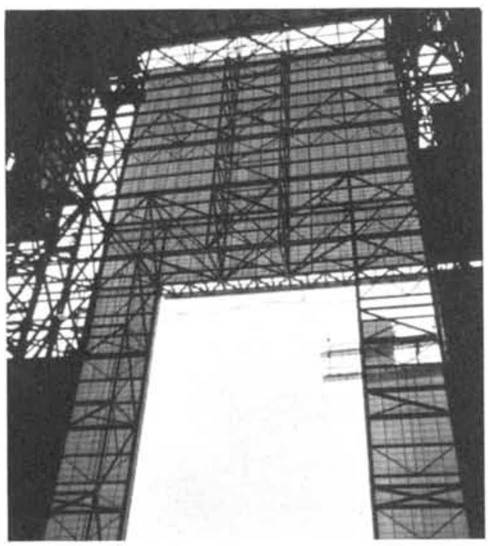


Apollo Assembly Building, Cape Kennedy, Florida



To introduce natural light into this huge building for the Apollo program a large part of one wall is composed of translucent sandwich panels. The outer facing is covered with a thin transparent film of polyvinyl fluoride to afford additional protection against weathering and solar degradation.

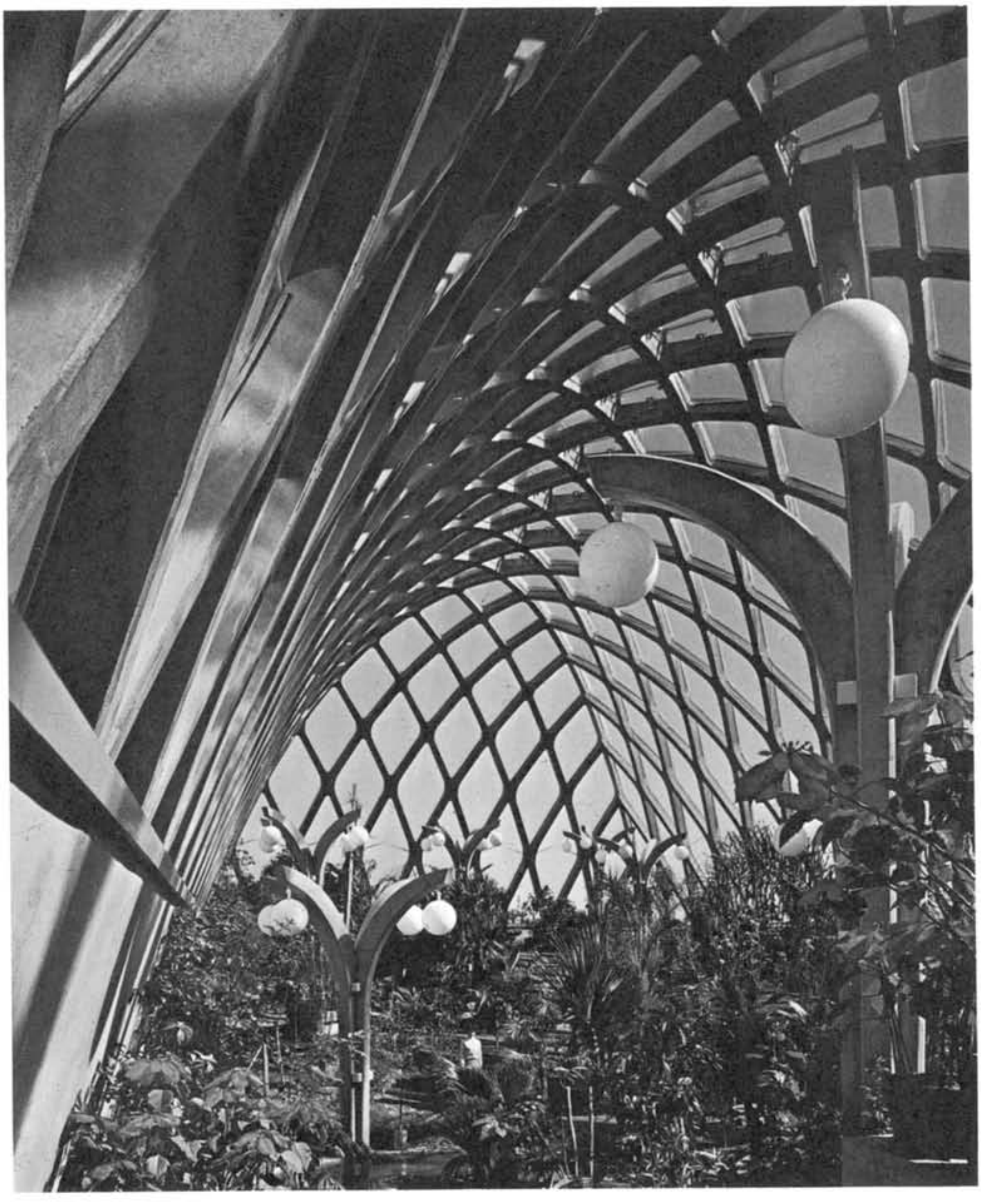
Translucent Wall Exterior and Interior



Denver Botanical Gardens, Interior

Vacuum-formed (Chapter 6) diamond-shaped acrylic bubbles combined with reinforced concrete ribs form the envelope of these botanical gardens. Clear acrylics are among the best transmitters of solar radiation. They are opaque to long-wave radiation from warm objects within a space and thus provide a "greenhouse" effect.

Detail of Concrete Ribs and Acrylic Bubbles



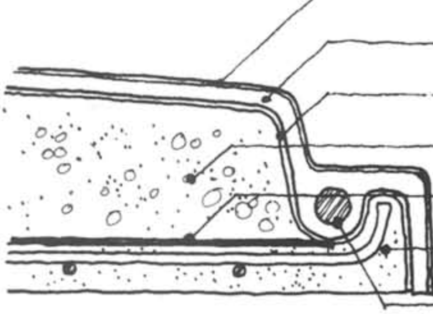
Molded Bathroom, Model

Molded bathroom components may consist of shower bases and walls, tubs and integral surrounding walls, and other molded fixtures and wall sections, or molded bathroom halves (floor-wall, ceiling-wall). Components can be assembled offsite into complete bathrooms.

Thermoformed polyvinyl chloride sheets provide the façade of this commercial building. Such sheets are employed for external and internal wall covering because of their weather resistance, resistance to wear and tear, and colorability.

Thermoformed PVC Façade, Germany

Greater London Council, High-Rise Flats



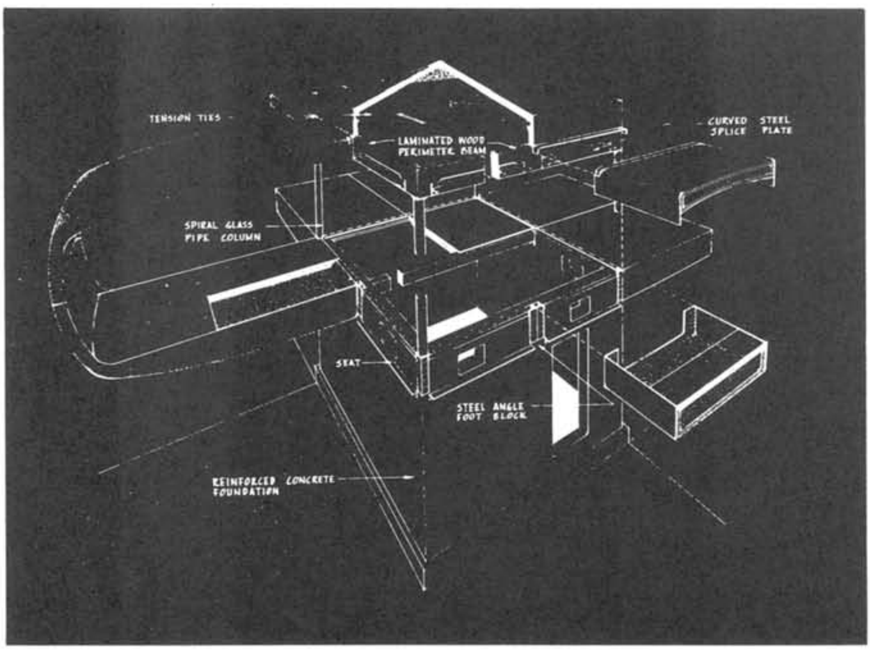
Composite sandwich panels of glass-fiber reinforced polyester shells bonded to foamed concrete cores, with reinforced gypsum inner facing, provide wall panels weighing one fifth as much as standard construction, resistant to high winds, meeting fire-safety requirements, possessing low thermal transmission, and providing high acoustical impedance.

Six Preassembled Panels Erected At Once

Detail, Wall Panels

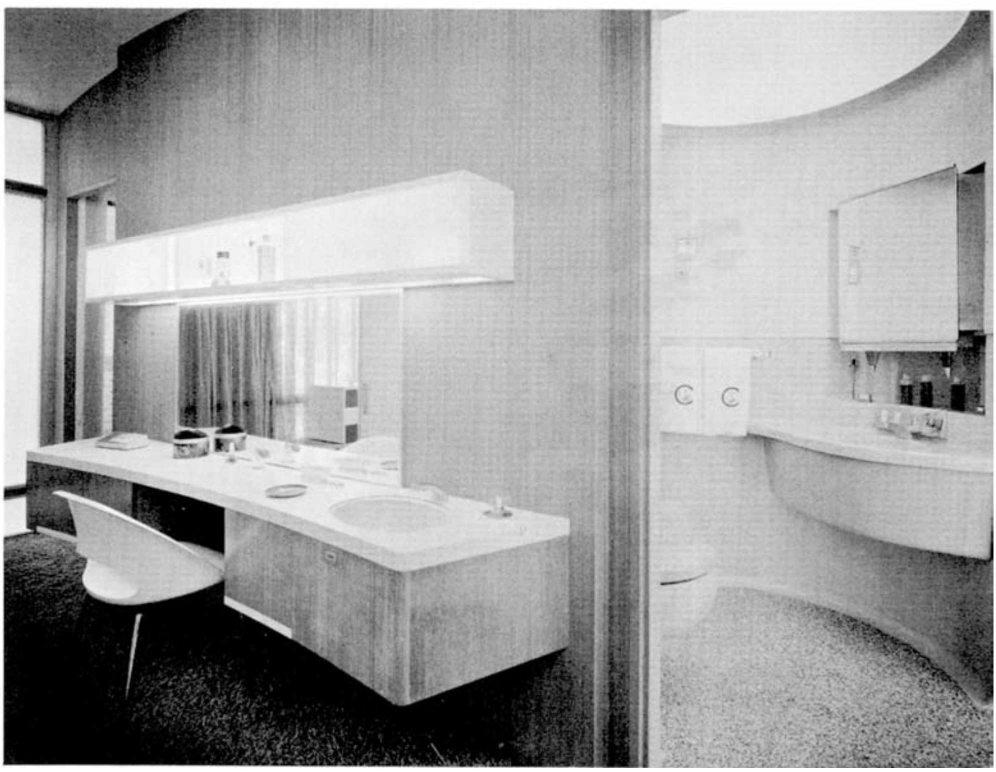
"House of the Future"

Monocoque Shell Structure



Full advantage was taken of the ability of reinforced plastics to provide strong, stiff, doubly-curved shells for the four cantilevered, self-supporting wings of this cross-shaped house. The floor was a sandwich with reinforced plastics upper and lower faces bonded to a honeycomb core of phenolic resin impregnated paper. The lower shell and floor sandwich were bonded together at their edges to form true monocoque "wings" designed to resist the full floor load, snow load, earthquakes, and ninety-mph winds. The house had an average of 2,000,000 visitors per year during its ten-year life and withstood moderate earthquakes and high winds with no discernible distortion or sign of distress.

Bathrooms were premolded of reinforced plastics in two parts, joined at the site. Flooring, wall coverings, piping, foam insulation, and other features all utilized plastics. Windows were laminated glass with a polyvinyl butyral interlayer.

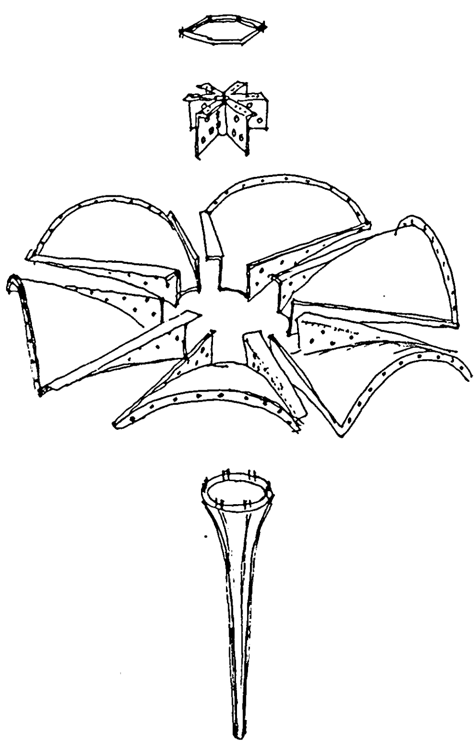


Molded Bathroom

Ninety "umbrellas" of molded random fiber-reinforced plastics (Chapter 5), each 20 feet high and 16 feet across its hexagonal top, were erected in 1959 in Moscow as part of the United States exhibition. Hollow columns and ribs were approximately 1/4-inch thick; the six highly translucent, doubly curved "petals" were 1/16-inch thick. Designed for one summer's use only, plastics were selected for fire resistance but not for weather resistance (Chapter 4), and no protective treatment was employed. Many of these umbrellas were later re-erected in the Crimea, where after seven to eight years' exposure they were reported to be in good condition.

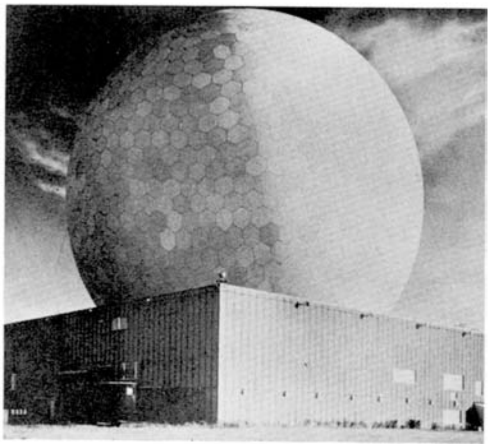
Reinforced Plastics Canopies, Moscow

Exploded Diagram



Canopies in Place

Radome,
Hexagonal
Sandwich
Structure



Inflated
Radome

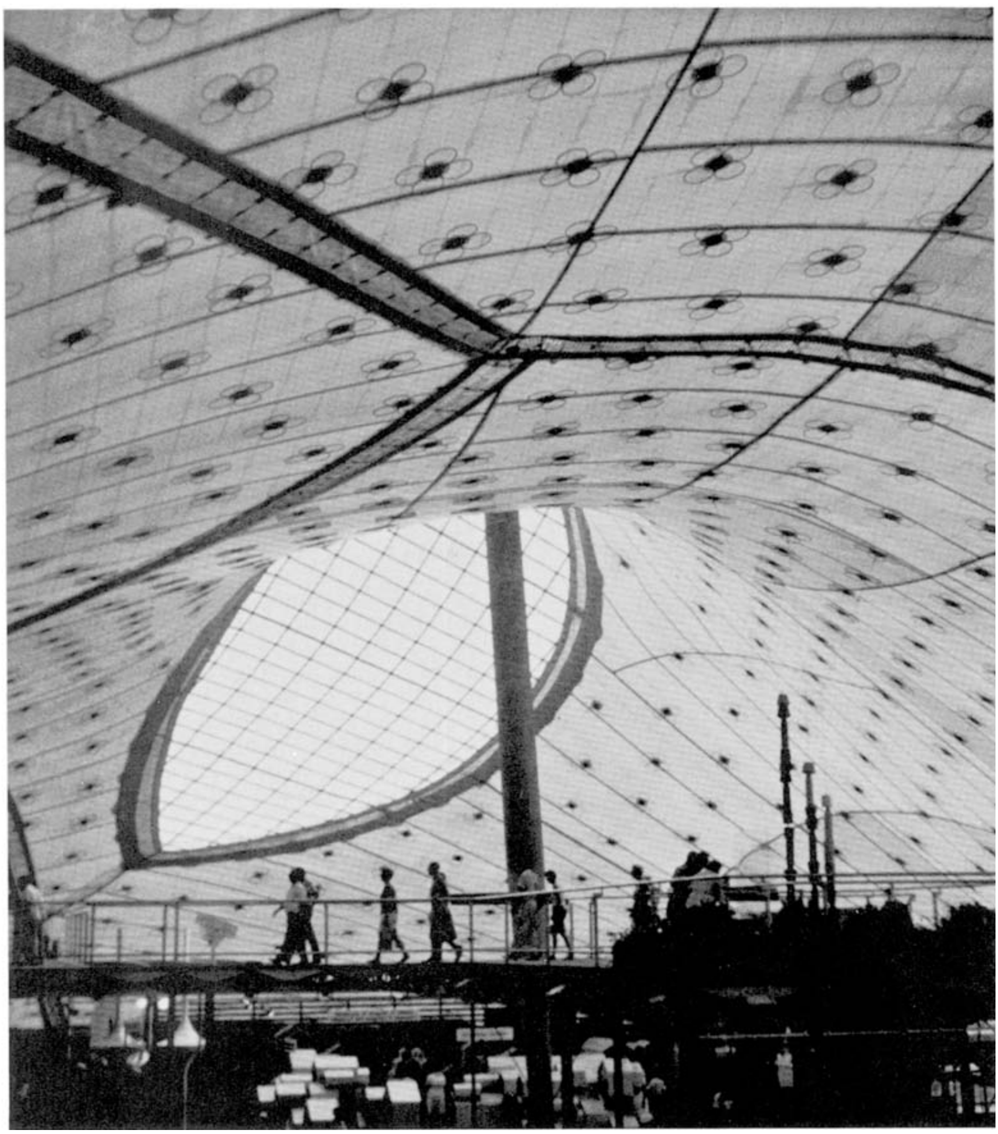
Diagrammatic
Cutaway
Section

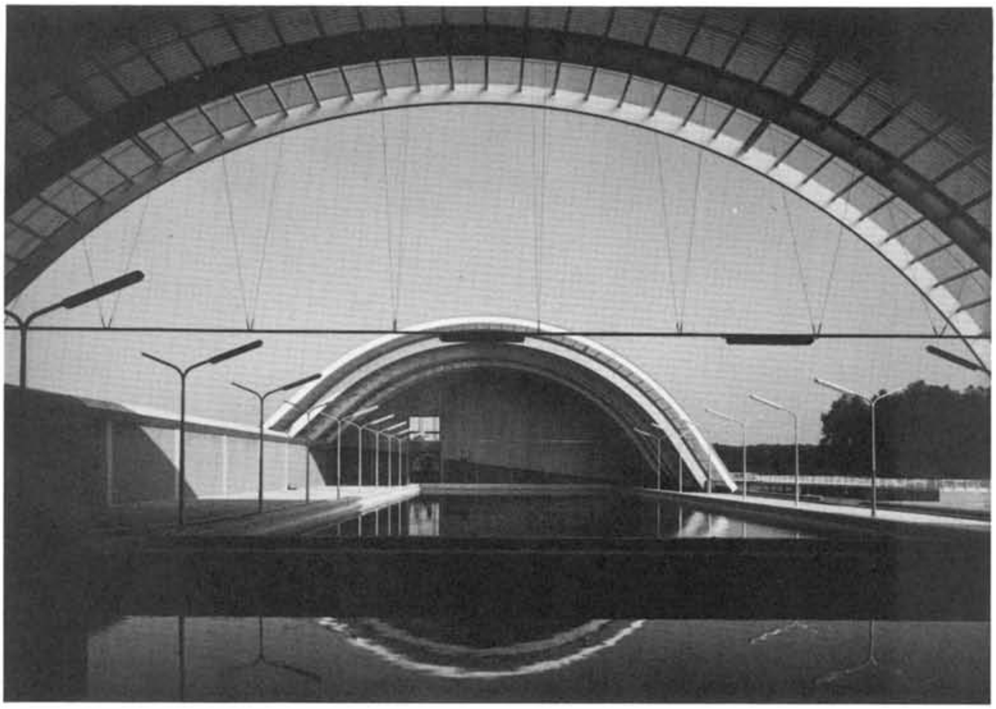
Radome,
Metal Frame,
Reinforced
Plastic Skin

Radomes, ranging from a few feet to 150 feet in diameter, are typically made of triangular, hexagonal, or "orange-peel" premolded parts, commonly with random-fiber reinforced plastics skins or membranes molded to integral edge ribs. Parts are bolted together. Larger radomes have metal ribs, some very large ones are sandwiches (Chapter 5) with reinforced plastics facings on honeycomb cores. Still others are an assemblage of metal bars in a triangular-pentagonal-hexagonal arrangement to which sheets of reinforced plastics are attached, or else they are made of inflated coated fabric. Typically, radomes are designed for 150-mph winds and temperatures ranging from arctic to tropical.

Large areas can be covered with tension structures in which a membrane is stretched between supporting columns and anchorages. In this building a system of cables under tension supports a stretched membrane of plastic-coated fabric, with transparent zones of clear plastic membrane interspersed.

German Pavilion, Expo '67 Montreal





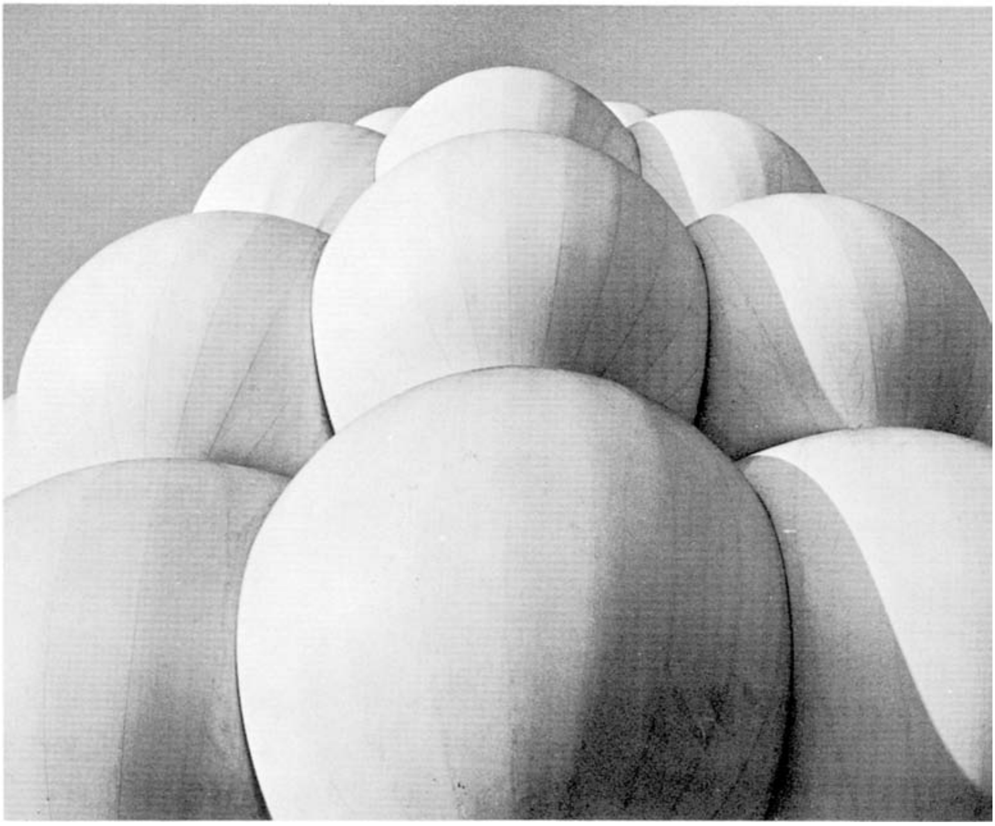
PVC Swimming Pool Roof

Light-transmitting vaulted roofs may be constructed of corrugated plastic sheet supported by a framework of other materials, e.g., steel, laminated wood, concrete, or aluminum. Connections of sheet to roof should allow for expansion and contraction with temperature changes.

Flexible Connection, Corrugated Sheet to Support

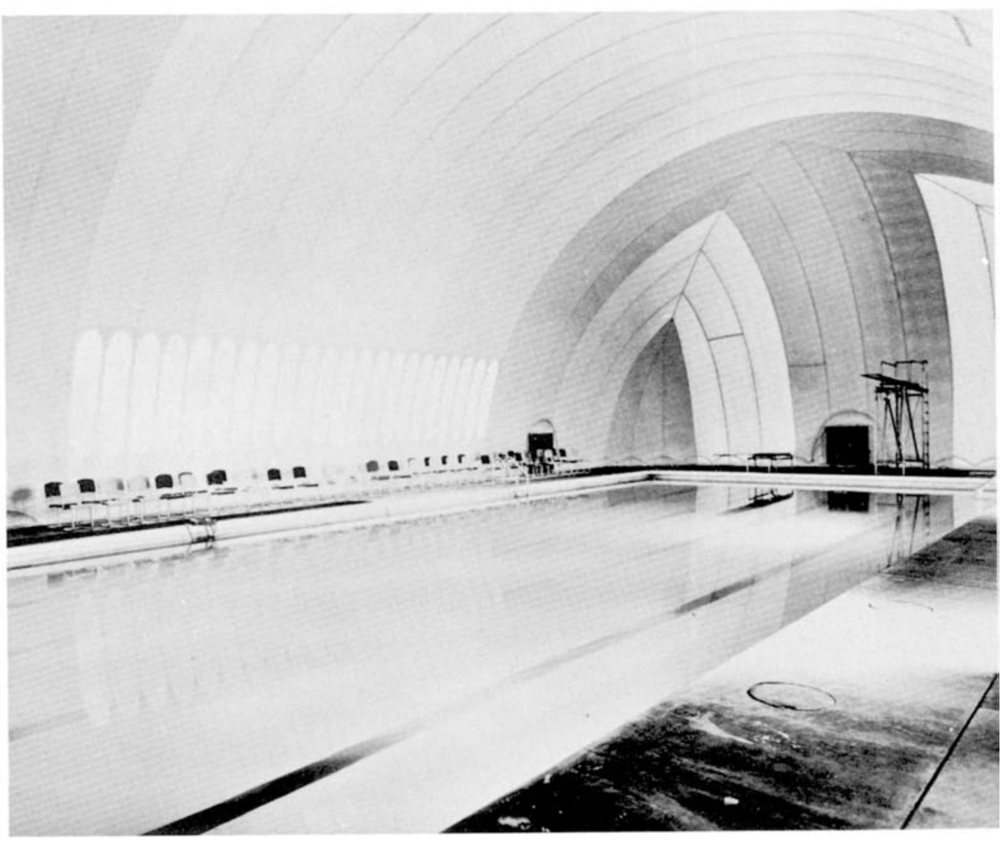
Applying Corrugated Sheet

Clustered
Inflated
Structure



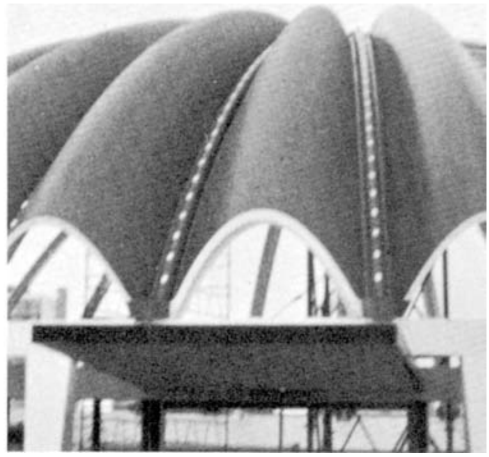
Constructing
Small Building
In Inflated
Enclosure

Plastic-coated fabric is commonly employed for air-supported buildings, such as covers for swimming pools, storage areas, small commercial buildings, radomes, and shelters during construction. The entire volume inside the building may be under small positive pressure, or else the structure may employ inflated double walls or ribs.



Air-Supported Swimming Pool Enclosure

Market,
Argenteuil,
France,
Construction
Detail



Doubly curved conoids of glass-fiber reinforced polyesters (Chapter 5) form the roof of this 100-ft.-diameter market. A steel-pipe frame provides the outer tension ring and the small compression ring at the top.

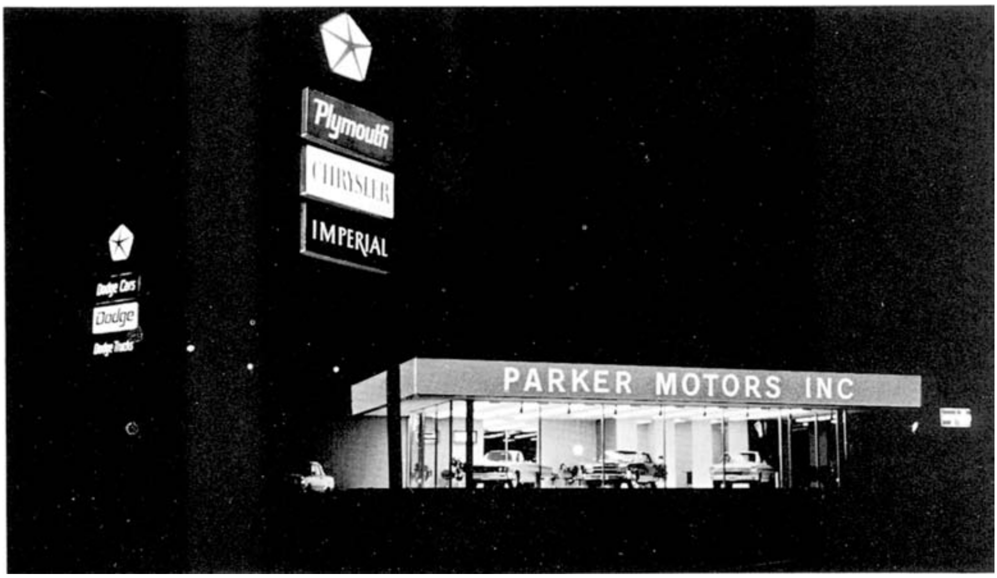
Finished
Market

The curved skylight consists of acrylic sheets formed to the desired curvature and mounted on curved ribs.

Marin County Center, California

Roof Fascia,
Formed Acrylic

Illuminated
Signs

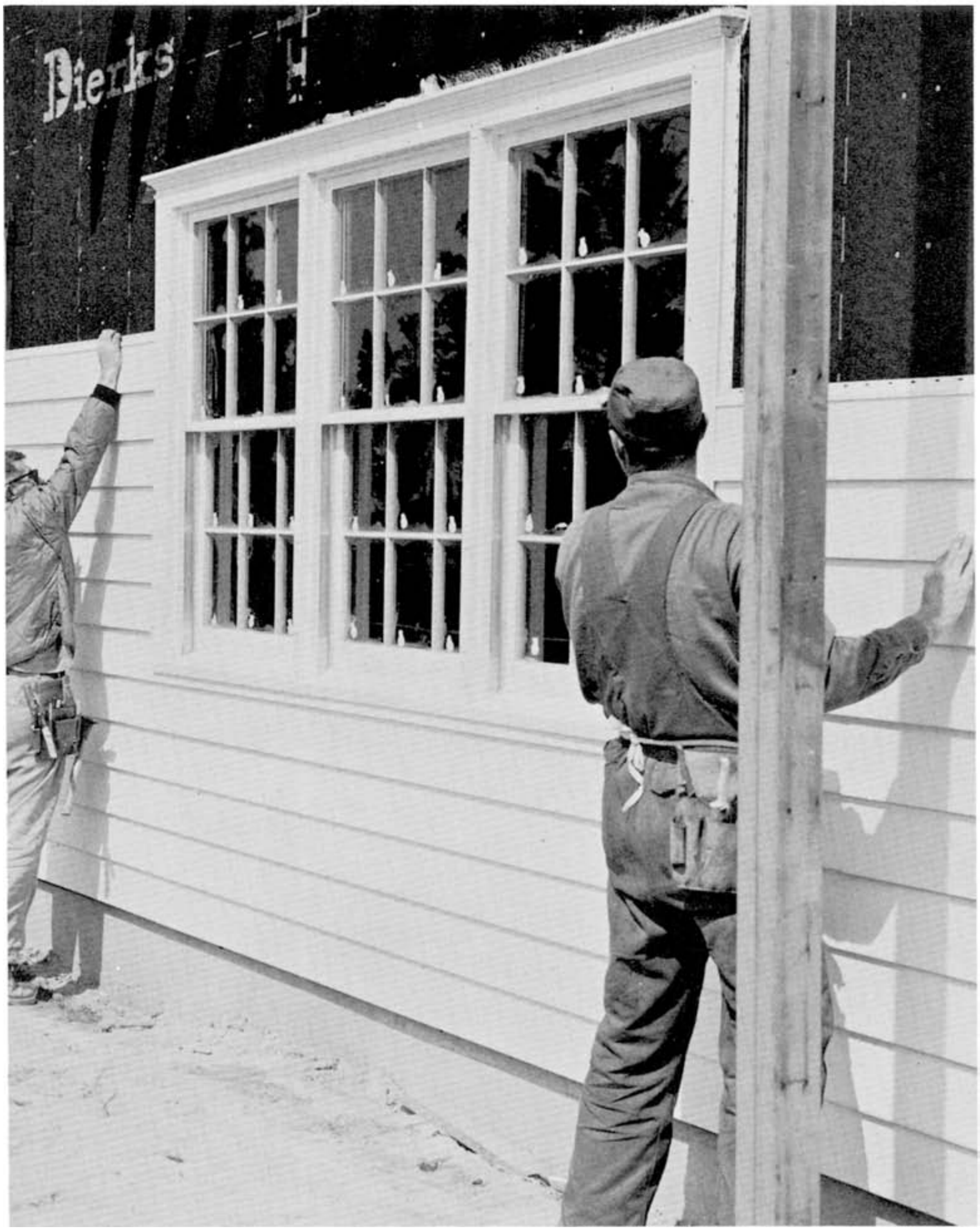


Façade,
Thermoformed
Acrylic

Exterior and interior illumination, signs, and shatter-resistant glazing make extensive use of plastics, in various combinations of clarity, translucence, color, pattern, figure and pictorial representation. Among the materials most commonly employed are acrylics, vinyls, acetate-butyrate, reinforced plastics, carbonates and, in addition, for interiors, styrene, plus various others (Chapter 2).

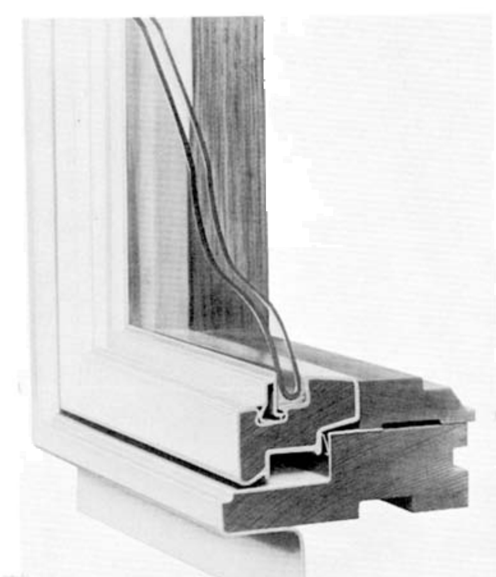
Plastics are employed in various ways for exterior cladding of buildings. Sheets are formed into a multitude of patterns by embossing, deep thermoforming, and interlocking extruded shapes. Deeply sculptured patterns may provide stiffness and rigidity, highlights and shadows, and permit dimensional variations with temperature changes to be accommodated within the sheet without causing over-all expansion and contraction.

Façade, PVC
Frankfurt,
Germany

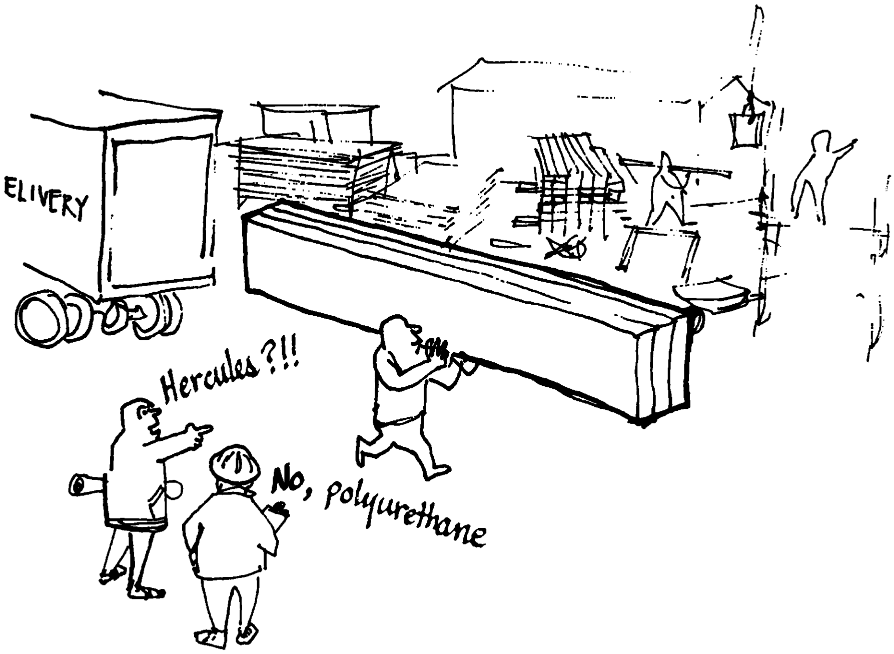


Clapboards with various profiles and interlocking edges are extruded for use in facing of houses and similar structures. Color is integral and material is dent-resistant. Allowance must be made for expansion and contraction with temperature changes.

Windows employ plastics in a variety of ways, from complete windows to accessories, such as parting strips, moldings, and weatherstripping. Window sash and frames may have a metal or wood core with plastic overlay, as in the PVC-covered sash and frame illustrated.



PVC-Covered Wood Windows



Hyperbolic Paraboloid Formed with Polystyrene Foam Planks

Concrete Deposited on Foam

Many plastics can be expanded into low-density foams (Chapter 6) possessing low coefficients of heat transmission. In building, the most commonly employed are polystyrene and polyurethane. Principal uses are for cold-storage insulation, furring and plaster base on masonry, cavity wall insulation, residential sheathing and insulation, backerboard for metal siding, perimeter and slab insulation, sound isolation, roof insulation, concrete form liners and sculptured effects, and cores of structural sandwich panels (Chapter 5). Other foams of interest are phenolic, polyvinyl chloride, cellulose acetate, and polyethylene.

Polystyrene Foam Base for Plaster

Concrete Wall Panels With Polystyrene Foam Insulating Layer, Prague

Decorative laminates (Chapter 5) are standard materials for counters, many furniture parts such as table tops, and wall covering. The sheets may be flat, backed with plywood or other board, and edged with strips of the same material or with wood, metal, other materials. Postformed sheets may provide integral rounded edges and coves. Because they are thermosets (Chapter 2) they may be employed at temperatures approaching the original pressing temperature without danger of softening.

Transparent and translucent plastics are widely employed for over-all ceiling illumination. Sheets are commonly corrugated or thermoformed (Chapter 6) into pans or other shapes as needed for the installation.

Large Illuminating Ceiling Panels

Luminous Ceiling

Lightweight PVC Piping

Plastics Water Pipe

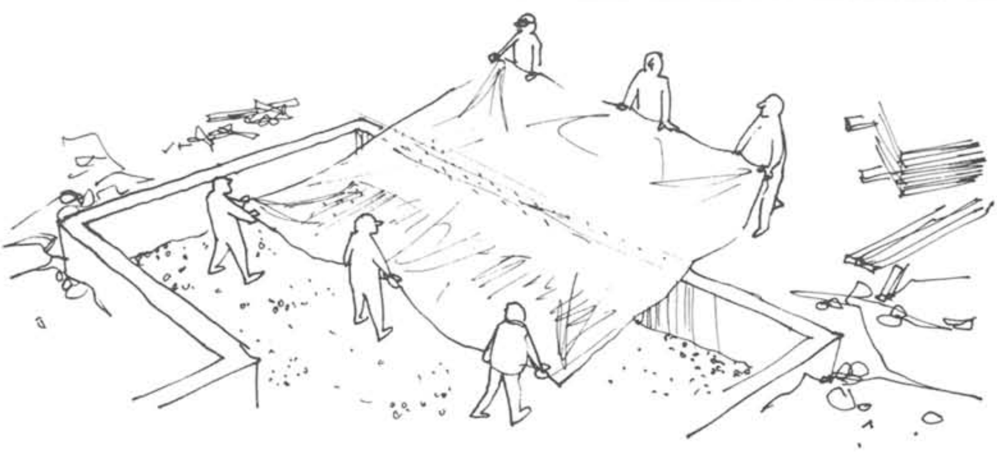
Preassembled Plumbing Tree

Lightness and corrosion resistance make plastics or plastic-lined piping attractive for water supply, waste lines, and vents and for the handling of a wide variety of fluids that would corrode or be contaminated by metallic materials. Depending upon the fluid to be handled, any one of a large variety of plastics may be employed. Lightness and toughness make plastics especially attractive for prefabricated plumbing trees which are easily transported and installed.

Flexible, impermeable, wide (30 feet or more, Chapter 6) films of polyethylene are commonly used under concrete slabs on grade. The film is reasonably resistant to puncturing and is inert to most soil conditions. Wide sheets reduce the number of joints.

Plastic Film Moisture Barrier

Casting Concrete on Film



Spreading Film for Moisture Barrier

Patterned PVC Flooring

PVC Flooring in Sheet Form

Toughness, wear resistance, good stain and chemical resistance, color, pattern, and availability as tile or sheet have brought vinyls (Chapter 2) to the forefront among flooring materials. Colors and patterns, calendered or chips in matrix (Chapter 6) are almost unlimited and may be integral or surface-printed. Materials can be cut to design. Being thermoplastic (Chapter 2) they can be heat-softened and bent as, for example, in coves. Various substrates such as concrete and wood may be employed. Vinyls can be placed on concrete on grade with the proper cements.

Terrazzo flooring utilizing epoxies or polyesters as binders has essentially the same attributes as conventional terrazzo but can be much thinner because of the toughness of the binder and its strong adhesion to the substrate.

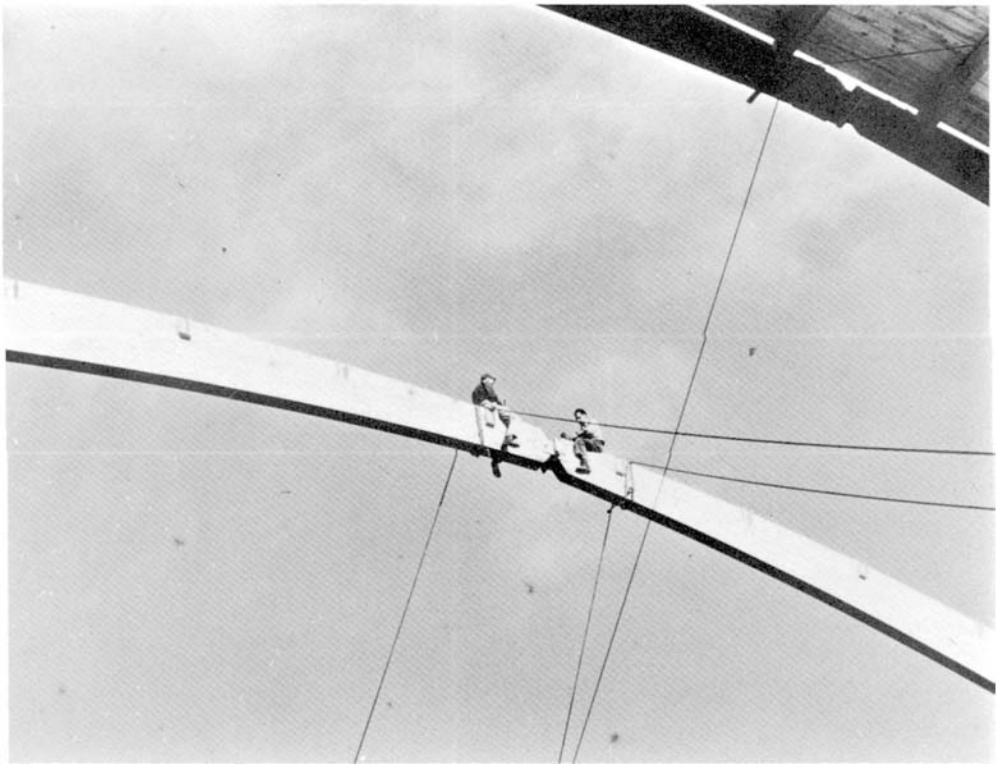
Epoxy-based mortars are utilized for leveling and for patching concrete. As in the terrazzos, the toughness and adhesion of the epoxy binder allow such layers to be thin.

Embossed and printed patterns (Chapter 6) in a great variety of colors and figures can be obtained in flexible sheets, of which the vinyls (Chapter 2) are most commonly employed. A clear plastic overlayer, plain or embossed, may protect the colored pattern. For added strength or to facilitate bonding to a substrate the plastic sheet may be "supported," that is, reinforced or backed with fabric, paper, felt, or flock. The proper adhesive must be selected.

PVC
Wall
Covering

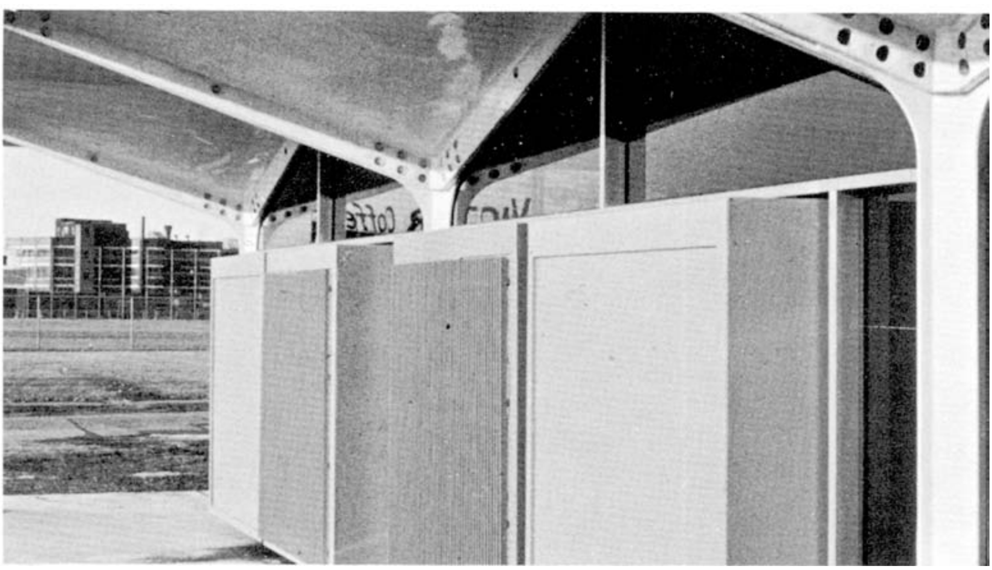
Floor,
PVC Tiles

Laminated Timber Arches



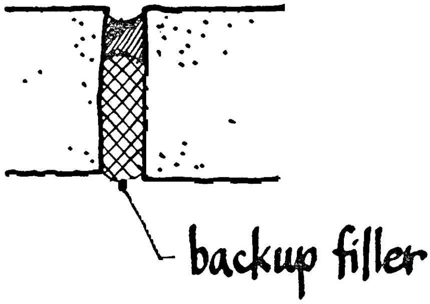
High-strength durable engineering adhesives are one of the forms in which plastics act as auxiliaries to other materials. In the large timber arches shown, resorcinol-formaldehyde provides the bond between the laminations and makes possible the fabrication of highly moisture-resistant glued timber members of sizes and shapes possible to attain only by laminating.

In the small prototype school house, the roof consists of eight-foot square hyperbolic paraboloids two inches thick, with 1/16-inch thick glass-fiber reinforced facings on a foamed-in-place polyurethane core. Hypars are bolted to tops of hollow metal columns. All units are small and light enough to be readily transported and erected without power equipment. Parts can be demounted and rearranged, or transported to another site.

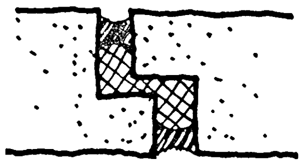


Hypar Sandwiches, R/P Faces and Foam Core

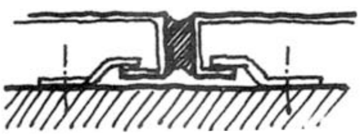
Sealant in
Simple
Masonry
Butt Joint



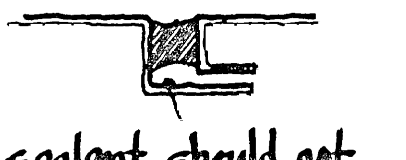
Shiplapped
Masonry
Butt Joint



Metal
Butt Joint



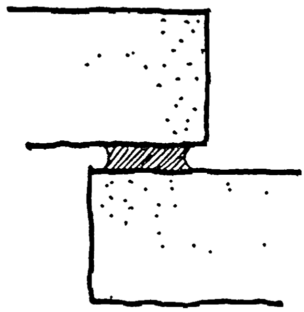
Offset
Metal
Butt Joint



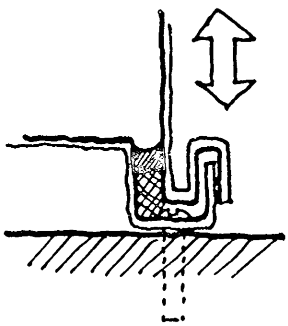
Polymers such as polysulfides, acrylics, silicones, urethanes, and butyls provide sealants not previously available for increasingly exacting building applications. These include glazing, curtain walls, joints between industrialized components, and the sealing of combinations of materials not hitherto found in buildings. Principles governing the proper design of joints, such as the lap and butt joints in masonry and metal shown in the sketches, are being clarified. Nevertheless, sound workmanship is essential, as it is in most other aspects of building.

The joints shown on this page are working butt joints, i.e., joints in which motion occurs that alternately squeezes and extends the sealant. It should not be too thick with respect to its width.

Joints shown on page 43 are working lap joints; here motion occurs that puts the sealant in shear. It must be thick and flexible enough to withstand such repeated motion without tearing.



Sealant in
Masonry
Lap Joint



Offset
Metal
Lap Joint

Simple
Metal
Lap Joint